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INVENTION: ENCODING APPARATUS, ENCODING METHOD, DECODING
APPARATUS, DECODING METHOD, AND RECORD MEDIUM

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(2) that she translated Japanese Application 10-283991 from
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October 6, 2004

Date

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[Title of Document] Specification

[Title of the Invention] Picture Signal Encoding
Apparatus, Picture Signal Encoding Method, Picture
Signal Decoding Apparatus, Picture Signal Decoding
5 Method, Picture Information Processing System, and
Picture Information Processing Method

[Scope of Claims for a Patent]

[Claim 1]

10 A picture signal encoding apparatus,
comprising:

uniformly distributed random number
generating means for generating uniformly distributed
random numbers; and

15 encoding means for referencing a threshold
value designated corresponding to a random number
generated by said uniformly distributed random number
generating means and digitizing pixel values of an
original picture signal that is successively input.

[Claim 2]

20 A picture signal decoding apparatus for
receiving an encoded output signal of which pixel
values of an original picture signal that is
successively input are digitized with reference to a
threshold value designated corresponding to uniformly
25 distributed random numbers, comprising:

sampling means for sampling the encoded
output signal;

counting means for counting the number of
times of the sampling process performed by said
sampling means;

5 storing means for cumulating sampled values
obtained by said sampling means; and

calculating means for dividing the cumulated
value generated by said storing means by the counted
value obtained by said counting means.

[Claim 3]

10 A picture information processing system,
comprising:

uniformly distributed random number
generating means for generating uniformly distributed
random numbers;

15 a picture signal encoding device for
referencing a threshold value designated corresponding
to a random number generated by said uniformly
distributed random number generating means and
digitizing pixel values of an original picture signal
20 that is successively input;

sampling means for sampling the encoded data
that is output from said picture signal encoding
device;

25 counting means for counting the number of
times of the sampling process performed by said
sampling means;

storing means for cumulating sampled values

obtained by said sampling means; and

calculating means for dividing the cumulated value generated by said storing means by the counted value obtained by said counting means.

5 [Claim 4]

The picture information processing system as set forth in claim 3,

10 wherein each pixel value of the decoded picture is calculated corresponding to an output signal of said calculating means.

[Claim 5]

The picture information processing system as set forth in claim 3,

15 wherein the sampling period of said sampling means is varied.

[Claim 6]

The picture information processing system as set forth in claim 5,

20 wherein the sampling period of said sampling means is designated corresponding to the picture quality required for a picture decoded by said picture signal decoding device.

[Claim 7]

25 The picture information processing system as set forth in claim 3,

wherein when a predetermined condition is satisfied, the output of the encoded data is stopped.

[Claim 8]

The picture information processing system as
set forth in claim 7,

5 wherein the predetermined condition is
satisfied when a determination for a sufficient picture
quality of a picture decoded by said picture signal
decoding device has been successfully performed.

[Claim 9]

10 The picture information processing system as
set forth in claim 8,

 wherein the determination is performed by the
user.

[Claim 10]

15 The picture information processing system as
set forth in claim 3,

 wherein said storing means generates the
cumulated value in such a manner that the relation
between each digitized value of the encoded data and
each pixel value of the decoded picture is different
20 from the relation between each digitized value of the
encoded data and each pixel value of the decoded
picture.

[Claim 11]

25 The picture information processing system as
set forth in claim 3,

 wherein the original picture signal is a
digital signal.

[Claim 12]

The picture information processing system as set forth in claim 3,

wherein the original picture signal is an analog signal.

[Claim 13]

A picture signal encoding method, comprising the steps of:

(a) generating uniformly distributed random numbers; and

(b) referencing a threshold value designated corresponding to a random number generated at step (a) and digitizing pixel values of an original picture signal that is successively input.

[Claim 14]

A picture signal decoding method for receiving encoded data of which pixel values of an original picture signal that is successively input are digitized with reference to a threshold value designated corresponding to uniformly distributed random numbers, comprising the steps of:

(a) sampling the encoded output signal;

(b) counting the number of times of the sampling process performed at step (a);

(c) cumulating sampled values obtained at step (a); and

(d) dividing the cumulated value generated at

step (c) by the counted value obtained at step (b).

[Claim 15]

A picture information processing method,
comprising the steps of:

5 (a) generating uniformly distributed random
numbers;

 (b) referencing a threshold value designated
corresponding to a random number generated at step (a)
and digitizing pixel values of an original picture
10 signal that is successively input so as to obtain
encoded data of the picture signal;

 (c) sampling the encoded data;

 (d) counting the number of times of the
sampling process performed at step (c);

15 (e) cumulating sampled values obtained at
step (c); and

 (f) dividing the cumulated value generated at
step (e) by the counted value obtained at step (d).

[Detailed Description of the Invention]

20 [0001]

[Industrial Field of Utilization]

 The present invention relates to a picture
signal encoding apparatus, a picture signal encoding
method, a picture signal decoding apparatus, a picture
25 signal decoding method, a picture information
processing system, and a picture information processing
system.

[0002]

[Prior Art]

A conventional signal format for transmitting picture information is defined considering a particular resolution, a particular number of gradation levels, and so forth. Thus, the resolution, the number of gradation levels, and so forth of a picture decoded corresponding to transmitted information depend on those of a picture that has been encoded.

[0003]

A signal format of which a resolution range and a gradation range are hierarchically recorded is known. However, in such a signal format, the selection ranges for the resolution and the number of gradation levels are pre-limited. Alternatively, many calculations are required in the decoding process. In addition, a circuit dedicated for the calculations is required. Thus, the conventional format cannot be used generally and practically.

[0004]

[Subject that the Invention is to solve]

Therefore, a picture format that allows the resolution, the number of gradation levels, and so forth of decoded data to be freely selected has been desired.

[0005]

Therefore, an object of the present invention

is to provide a picture signal encoding apparatus, a picture signal encoding method, a picture signal decoding apparatus, a picture signal decoding method, a picture information processing system, and a picture information processing system that accomplish a picture format that allows the resolution and the number of gradation levels of decoded data to be freely selected.

[0006]

[Means for Solving the Problem]

Claim 1 of the present invention is a picture signal encoding apparatus, comprising a uniformly distributed random number generating means for generating uniformly distributed random numbers, and an encoding means for referencing a threshold value designated corresponding to a random number generated by the uniformly distributed random number generating means and digitizing pixel values of an original picture signal that is successively input.

[0007]

Claim 2 of the present invention is a picture signal decoding apparatus for receiving an encoded output signal of which pixel values of an original picture signal that is successively input are digitized with reference to a threshold value designated corresponding to uniformly distributed random numbers, comprising a sampling means for sampling the encoded output signal, a counting means for counting the number

of times of the sampling process performed by the
sampling means, a storing means for cumulating sampled
values obtained by the sampling means, and a
calculating means for dividing the cumulated value
5 generated by the storing means by the counted value
obtained by the counting means.

[0008]

Claim 3 of the present invention is a picture
information processing system, comprising a uniformly
10 distributed random number generating means for
generating uniformly distributed random numbers, a
picture signal encoding device for referencing a
threshold value designated corresponding to a random
number generated by the uniformly distributed random
15 number generating means and digitizing pixel values of
an original picture signal that is successively input,
a sampling means for sampling encoded data that is
output from the picture signal encoding device, a
counting means for counting the number of times of the
20 sampling process performed by the sampling means, a
storing means for cumulating sampled values obtained by
the sampling means, and a calculating means for
dividing the cumulated value generated by the storing
means by the counted value obtained by the counting
25 means.

[0009]

Claim 13 of the present invention is a

picture signal encoding method, comprising the steps of
(a) generating uniformly distributed random numbers,
and (b) referencing a threshold value designated
corresponding to a random number generated at step (a)
5 and digitizing pixel values of an original picture
signal that is successively input.

[0010]

Claim 14 of the present invention is a
picture signal decoding method for receiving encoded
10 data of which pixel values of an original picture
signal that is successively input are digitized with
reference to a threshold value designated corresponding
to uniformly distributed random numbers, comprising the
steps of (a) sampling the encoded output signal, (b)
15 counting the number of times of the sampling process
performed at step (a), (c) cumulating sampled values
obtained at step (a), and (d) dividing the cumulated
value generated at step (c) by the counted value
obtained at step (b).

20 [0011]

Claim 15 of the present invention is a
picture information processing method, comprising the
steps of (a) generating uniformly distributed random
numbers, (b) referencing a threshold value designated
25 corresponding to a random number generated at step (a)
and digitizing pixel values of an original picture
signal that is successively input so as to obtain

encoded data of the picture signal, (c) sampling the
encoded data, (d) counting the number of times of the
sampling process performed at step (c), (e) cumulating
sampled values obtained at step (c), and (f) dividing
5 the cumulated value generated at step (e) by the
counted value obtained at step (d).

[0012]

According to the present invention, with
encoded data composed of repetition of similar
10 digitized information obtained by a digitized threshold
value, picture information can be transmitted.

[0013]

[Embodiment]

Next, with reference to Fig. 1, the overall
15 structure of an information processing system according
to an embodiment of the present invention will be
described. In Fig. 1, an encoding device 100 has a
uniformly distributed random number generator 110 and a
quantizing device 120. An original picture signal is
20 supplied to the quantizing device 120. Uniformly
distributed random numbers generated by the uniformly
distributed random number generator 110 are supplied to
the quantizing device 120. The quantizing device 120
raster-scans the original picture signal and digitizes
25 each pixel value of the original picture signal with a
threshold value of the random number received from the
uniformly distributed random number generator 110. The

quantizing device 120 repeats this operation for example 4096 times so as to generate a code (referred to as encoded data) as a set of digitized values. The uniformly distributed random number used as the threshold value is in a dynamic range that represents each pixel value of the original picture signal.

[0014]

The encoded data generated by the encoding device 100 is supplied to a transmission signal generating device 200. The transmission signal generating device 200 adds synchronous signals such as a horizontal synchronous signal, a vertical synchronous signal, and a sequential picture synchronous signal to the encoded data received from the quantizing device so as to generate a transmission signal. The synchronous signals that are added to the encoded data are the same as for example synchronous signals for the NTSC system. The minimum information unit of the transmission signal in the decoding process is referred to as packet. The synchronous signals are added to particular positions of each packet. To suppress an error that takes place during the signal transmission from affecting the encoded data, before the encoded data is converted into the transmission signal, the encoded data may be rearranged.

[0015]

On the other hand, a decoding device 300 has

a sampling circuit 310, a cumulating circuit 320, and a decoding circuit 330. In the state that the horizontal synchronization, vertical synchronization, and entire picture synchronization are established corresponding to the synchronous signals of the transmission signal, the sampling circuit 310 receives the transmission signal, samples the encoded data of the received transmission signal and supplies the sampled values to the cumulating circuit 320. The cumulating circuit 320 cumulates the sampled values and updates the number of sampling times. The decoding circuit 330 calculates each pixel value of the decoded picture corresponding to the cumulated digitized value and the number of sampling times.

[0016]

Next, the encoding process of the encoding device 100 for the original picture signal will be described in detail. First of all, as an example of the digitizing process for one pixel value, the case of which one pixel value is 184 in the gradation level ranging from 0 to 255 as shown in Fig. 2 will be described. In this example, the pixel value is repeatedly digitized 11 times with 11 types of threshold values that are uniformly distributed in the range from 0 to 255. The ratio of values of 184 or smaller to these threshold values is almost equal to the ratio of 184 to 255.

[0017]

In other words, since the value of $(184 \div 255) \times 11$ is around 7.9, eight types of threshold values are 184 or smaller. Thus, eight of 11 digitized values obtained in the digitizing process performed 11 times are for example "1". The other three digitized values are for example "0". However, when a threshold value is equal to or smaller than a pixel value, the digitized value may be "0". Otherwise, the digitized value may be "1". More generally, the relation expressed by formula (1) is satisfied.

[0018]

[Formula 1]

$$I / D \approx P \quad \dots (1)$$

where I is a pixel value; D is a gradation level; and p is the ratio of which a threshold value is equal to or smaller than a pixel value.

[0019]

With encoded data as a set of digitized values obtained by the digitizing process with reference to many threshold values that are uniformly distributed, each pixel value of an original picture is represented. In other words, in the above-mentioned example, since the number of "1s" of 11 digitized values is 8, because of $255 \times (8 / 11) \approx 185$, the calculated result is around 185. Thus, it is clear that the calculated result that is almost equal to the

original pixel value (184) can be restored. The decoding device 300 decodes pixel values of the original picture corresponding to such a theory.

[0020]

5 The accuracy of encoded data that represents pixel values of an original picture signal is proportional to the number of times of digitizing process (namely, the number of threshold values that are uniformly distributed and referenced in the digitizing process). As a method for generating threshold values that are uniformly distributed, according to the embodiment of the present invention, uniformly distributed random numbers are used.

[0021]

15 Next, with reference to Fig. 3, the case of which the above-described encoded data generating process is performed for one frame of a picture signal will be described. Fig. 3A shows an example of an original picture. In the example, the original picture is composed of 660 x 220 pixels (each pixel has eight bits = 256 gradation levels). In addition, the original picture has three channels of R, G, and B. All the picture signal of the original picture is digitized in the raster-scan method with threshold values of uniformly distributed random numbers 4096 times in such a manner that the position is moved for the width of one pixel at a time. Thus, encoded data

as shown in Fig. 3B is obtained. It should be noted that the digitizing process may be performed other than 4096 times. As described above, the picture quality of a decoded picture obtained with encoded data is proportional to the number of times of the digitizing process for threshold values.

[0022]

In the example, the case of which the original picture signal is a digital signal represented with eight bits was described. However, the present invention can be applied to the case that the encoding process is performed with the original picture signal that is an analog signal. When the original picture signal is an analog signal, before the digitizing process for threshold values is performed, it is necessary to limit the amplitude of the signal in a predetermined width using for example an AGC (Automatic Gain Control) circuit. Regardless of whether the original picture signal is a still picture or a moving picture, the present invention can be applied.

[0023]

Next, the decoding process performed by the decoding device 300 will be described. In this example, the encoded data that has been generated in the above described method is decoded. In this case, the encoded data contained in the transmission signal can be treated as a virtual frame of which 660 x 4096

(= 2703360) pixels and 220 x 4096 (= 901120) pixels are arranged as a matrix in the horizontal direction and the vertical direction, respectively (see Fig. 4). A proper number of digitized values corresponding to the picture quality of a decoded picture to be generated is sampled from the virtual frame by the sampling circuit 310. As described above, the ratio of the number of "1s" of the sampled digitized values to the total number of sampled digitized values is approximated to that of which pixel values of the original picture are normalized in the range from 0 to 1.0.

[0024]

As the number of sampling times of the sampling circuit 310 increases (namely, the sampling period shortens), the approximation accuracy improves. Thus, a picture with a gradation similar to the original picture can be decoded. In reality, in consideration of a desired picture quality of a picture to be restored, the pixel values are thinned out to a required and sufficient number of pixels and then sampled. In this example, for simplicity, encoded data is treated as one frame. However, in reality, the sampling circuit 310 repeatedly samples encoded data generated corresponding to a sequence of an original picture signal.

[0025]

Alternatively, when the user thinks that a

decoded picture with a sufficient picture quality has been obtained in the middle of the signal transmission, he or she can control the sampling circuit 310 (with an operation panel or the like (not shown)) so that it stops receiving the transmission signal. Since the transmission signal containing encoded data corresponding to the present invention has a more information amount than the conventional signal format for transmitting picture information, when it is necessary to improve the efficiency of the data transmission to some extent, the process for stopping the reception of the signal is effective. Instead of the user's operation, a determining portion for determining the picture quality of a decoded picture may be disposed. When the determining portion determines that the picture quality is superior to a predetermined criteria, the determining portion may cause the sampling circuit 310 to stop receiving the transmission signal.

[0026]

On the other hand, the cumulating circuit 320 has a memory buffer (not shown), a memory (not shown), and so forth. The memory buffer cumulates digitized values received from the sampling circuit 310. The memory stores and updates the value of the cumulated times. When a picture signal is decoded for a long time, a record medium with a large storage capacity may

be used instead of the memory buffer. Examples of such a record medium are a tape and a disk.

[0027]

Thereafter, the decoding circuit 330 performs a process for calculates the pixel density corresponding to the cumulation value and the value of the cumulation times supplied from the cumulating circuit 320. In other words, the decoding circuit 330 divides the cumulation value by the value of the cumulation times and thereby obtains the pixel density of each pixel (namely, each pixel value of the original picture is normalized in the range from 0 to 1.0). In addition, by multiplying the pixel density by the number of gradation levels (such as 256 gradation levels) of the picture to be decoded, the decoding circuit 330 obtains a pixel value. In other words, with the gradation value D_r and the pixel density p , the decoding circuit 330 calculates a pixel value I corresponding to the following formula (2).

[0028]

$$I = D_r \times p \quad \dots (2)$$

According to the embodiment of the present invention shown in Fig. 1, encoded data generated by the encoding device 100 is directly supplied to the transmission signal generating device 200. The transmission signal generating device 200 converts the encoded data into a transmission signal and supplies it

to the decoding device 300. Alternatively, encoded data generated by the encoding device 100 or a transmission signal generated by the transmission signal generating device 200 may be recorded to a record medium. The encoded data or the transmission signal may be supplied to the decoding device 300 through the record medium. In other words, the present invention can be applied to a storage type broadcasting service.

[0029]

Next, processes according to the embodiment of the present invention will be described. With reference to a flow chart shown in Figs. 5 and 6, the encoding process will be described. Due to a limited space, the flow chart of the encoding process is shown in Figs. 5 and 6. In Figs. 5 and 6, X, P, Q, R, and S show step branch points. At step S1, the values of constants width, height, pixel, and line are set. The constants pixel and line represent the size of an original picture. In other words, the constant pixel represents the number of pixels in the horizontal direction of the original picture. The constant line represents the number of pixels in the vertical direction of the original picture (the number of lines that are raster-scanned). The constant width represents the number of pixels in the horizontal direction of an array of digitized values of encoded

data corresponding to one pixel of the original picture. The constant height represents the number of pixels in the vertical direction of an array of digitized values of encoded data corresponding to one pixel of the original picture.

[0030]

At steps S2 and S3, variables i and j are initialized, respectively. The variables i and j represent the current pixel position in the horizontal direction and the vertical direction of the original picture, respectively (namely, the coordinates of the current pixel of the original picture). At step S4, a pixel value $I(i, j)$ of coordinates (i, j) of the original picture is set as the value of a variable source that represents a pixel value of the original picture. At steps S5 and S6, variables v and h are initialized, respectively. The variable v and h represent the pixel position in the horizontal direction and the vertical direction in the array of digitized values of the encoded data corresponding to one pixel of the original picture.

[0031]

At step S7, the values of variables vv and hh that represent the data position in the encoded data of the digitized value obtained at step S8 are calculated. In other words, the variables vv and hh represent the vertical position and the horizontal position of the

digitized value in the encoded data (namely, the coordinates of the digitized value in the encoded data). The variable vv is calculated as the sum of $i \times$ height that represents the coordinate at the upper edge of the array of digitized values at the lower adjacent position of the array of digitized values corresponding to one pixel of the original picture containing the current data position and the variable v that represents the vertical coordinate of the current data position in the array of digitized values containing the current data position. The variable hh is calculated as the sum of $j \times$ width that represents the coordinate at the right edge of the array of digitized values at the left adjacent position of the array of digitized values corresponding to one pixel of the original picture containing the current data position and the variable h that represents the horizontal coordinate of the current data position in the array of digitized values containing the current data position.

[0032]

At step S7, a threshold value is designated. In this case, the product of the result of rand () that is a function for obtaining random numbers in the range from 0 to 1 and the maximum value of the dynamic range such as 255 is designated as the value of a variable thresh that represents the threshold value. The function rand () is a module for receiving random

numbers generated by the uniformly distributed random number generator 110 shown in Fig. 1. Alternatively, random numbers may be generated by software.

[0033]

5 Thereafter, the flow advances to step S8. At step S8, it is determined whether or not the value of the variable thresh is equal to or smaller than the value of the variable source. When the value of the variable thresh is equal to or smaller than the value of the variable source (namely, the determined result at step S8 is Yes), the flow advances to step S9. Otherwise, the flow advances to step S10. At step S9, a variable b that represents a digitized value is set to "1" (namely, b = "1"). On the other hand, at step 10 S10, the variable b is set to "0" (namely, b = "0"). Thus, the digitizing process is performed corresponding to the value of the variable thresh. Alternatively, at step S9, the variable a may be to "0" (namely, a = "0"); at step S10, the variable b may be set to "1" 15 (namely, b = "1").

[0034]

 After the operation at step S9 or S10 has been completed, the flow advances to step S11. At step S11, the value of the variable b is set as the value of 25 the digitized value at the coordinates (vv, hh) in the encoded data. Whenever the operation at step S11 is performed, one digitized value is decided. Thereafter,

the flow advances to step S12. At step S12, 1 is added to the value of the variable h. The operation performed at step S12 is equivalent to an operation of which the horizontal coordinate of the current pixel in the encoded data is moved by one position.

[0035]

Thereafter, the flow advances to step S13 shown in Fig. 6. At step S13, it is determined whether or not the value of the variable h is smaller than the value of the variable width (namely, the current pixel of the original picture exceeds the array of digitized values corresponding to one pixel of the original picture in the horizontal direction). When the value of the variable h is smaller than the value of the variable width (namely, the determined result at step S13 is Yes), the flow returns to step S7. At step S7, a digitized value is set with the value of the variable h that has been set at step S12. On the other hand, unless the value of the variable h is smaller than the value of the variable width (namely, the determined result at step S13 is No), the flow advances to step S14.

[0036]

At step S14, 1 is added to the value of the variable v. The operation performed at step S14 is equivalent to an operation of which the vertical coordinate of the current pixel in the array of

digitized values corresponding to one pixel of the original picture is moved by one position. After the operation at step S14 has been completed, the flow advances to step S15. At step S15, it is determined whether or not the value of the variable v is smaller than the value of the variable height (namely, the current pixel of the original picture exceeds the array of digitized values corresponding to one pixel of the original picture in the vertical direction). When the value of the variable h is smaller than the value of the variable height (namely, the determined result at step S15 is Yes), the flow returns to step S6. At step S6, the value of the variable h is initialized. Thereafter, a digitized value is set with the value of the variable v that has been set at step S14. On the other hand, when the value of the variable h is equal to or larger than the value of the variable height (namely, the determined result at step S15 is No), the flow advances to step S16.

[0037]

At step S16, 1 is added to the value of the variable j. The operation performed at step S16 is equivalent to an operation of which the current position of the original picture to be digitized with threshold values is moved in the horizontal direction by one position. After the operation at step S16 has been completed, the flow advances to step S17. At step

S17, it is determined whether or not the value of the variable j is smaller than the value of the variable pixel (namely, the value of the variable j does not exceed the number of pixels in the horizontal direction of the original picture). When the value of the variable j is smaller than the value of the variable pixel (namely, the determined result at step S17 is Yes), the flow returns to step S4. At step S4, the value of the variable source that represents the pixel value of the original picture is set with the value of the variable j that has been set at step S16. Thereafter, the digitizing process after step S5 is performed.

[0038]

On the other hand, when the value of the variable j exceeds the value of the variable pixel (namely, the determined result at step S17 is Yes), the flow advances to step S18. At step S18, 1 is added to the value of the variable i. The operation performed at step S18 is equivalent to an operation of which the pixel position of the original picture to be digitized with threshold values is moved in the vertical direction by one position. After the operation at step S18 has been completed, the flow advances to step S19. At step S19, it is determined whether or not the value of the variable i is smaller than the value of the variable line (namely, the value of the variable i does

not exceed the number of pixels in the vertical direction of the original picture). When the value of the variable i is smaller than the value of the variable line (namely, the determined result at step S17 is Yes), the flow returns to step S3. At step S3, the value of the variable j is initialized. Thereafter, pixels of the original picture are successively digitized with the value of the variable i that has been set at step S18.

10 [0039]

On the other hand, unless the value of the variable i is smaller than the value of the variable line (namely, the determined result at step S17 is Yes), it is determined that all pixels of the original picture have been digitized. Thus, the sequence of the encoding process is completed. In the above-described encoding method, each pixel of the original picture is digitized with threshold values given as random numbers so as to generate encoded data.

20 [0040]

Next, with reference to flow charts shown in Figs. 7 and 8, a decoding process will be described. Due to a limited space, the flow chart of the decoding process is shown in Figs. 7 and 8. In Figs. 7 and 8, Y represents a step branch point of the decoding process. At step S101, the values of variables pixel', line', and depth are set. The variable pixel' represents the

25

number of pixels in the horizontal direction of a
decoded picture. The variable line' represents the
number of pixels in the vertical direction of the
decoded picture. The variable depth represents the
5 maximum value of the gradation value of the decoded
picture. At step S102, the values of variables Tpixel
and Tline are received. The variable Tpixel represents
the number of pixels in the horizontal direction of the
encoded data. The variable Tline represents the number
10 of pixels in the vertical direction of the encoded
data. In this case, the values of the variables Tpixel
and Tline are contained in for example a header portion
or the like of the above-described transmission signal.

[0041]

15 At step S103, the values of variables width'
and height' are calculated and set. In other words,
the value of the variable Tpixel that represents the
number of pixels in the horizontal direction of the
encoded data is divided by the value of the variable
20 pixel' that represents the number of pixels in the
horizontal direction of the decoded picture so as to
calculate the value of the variable width' that
represents the number of pixels in the horizontal
direction of the array of digitized values
25 corresponding to one pixel of the decoded picture.
Likewise, the value of the variable Tline that
represents the number of pixels in the vertical

direction of the encoded data is divided by the value of the variable line' that represents the number of pixels in the vertical direction of the decoded picture so as to calculate the value of the variable height' that represents the number of pixels in the vertical direction of the array of digitized values corresponding to one pixel of the decoded picture.

[0042]

Thereafter, the transmission signal is sent.

At step S104, it is determined whether or not all data of the transmission signal has been sent. When all data of the transmission signal has been sent (namely the determined result at step S104 is Yes), the flow advances to step S111 shown in Fig. 8. Otherwise, the flow advances to step S105. After step S111, each pixel value of the decoded picture is calculated. The detail of this operation will be described later. At step S105, a digitized value $T(v, h)$ at coordinates (v, h) of the encoded data is received. Thereafter, the flow advances to step S106. At step S106, coordinates (i, j) of the pixel value of the decoded picture corresponding to the digitized value $T(v, h)$ are detected. In other words, the value of the variable i is calculated as an integer portion of which the value of the variable v is divided by the value of the variable height'. On the other hand, the value of the variable j is calculated as an integer portion of which

the value of the variable h is divided by the value of the variable width'.

[0043]

Thereafter, the flow advances to step S107.

5 At step S107, it is determined whether or not the digitized value T(v, h) is not "0". When the digitized value T(v, h) is not "0" (namely, the determined result at step S107 is Yes), the flow advances to step S108. Otherwise, the flow advances to step S109. At step
10 S108, 1 is added to a variable cnt [i] [j] that is a matrix. The variable cnt [i] [j] is a variable used to count the number of digitized values that are not "0" corresponding to pixels at coordinates (i, j) of the decoded picture. Whenever it is determined that the
15 digitized value T(v, h) is not "0" (namely, the determined result at step S107 is Yes), the value of the variable cnt [i] [t] increments by 1. Finally, the total number of digitized values that are not "0" corresponding to the pixels of the coordinates (i, j)
20 of the decoded picture is stored as the value of the variable cnt [i] [j]. After the operation at step S107 is completed, the flow advances to step S109.

[0044]

25 In the decoding process, the case that unless the digitized value T(v, h) is not "0" the digitized value is equal to or smaller than a threshold value was described. Thus, when the digitized value T(v, h) is

not "0" (namely, the determined result at step S107 is Yes), 1 is added to the value of the variable cnt [i] [j]. On the other hand, in the decoding process of which when the digitized value T(v, h) is "0", the digitized value is equal to or smaller than a threshold value, when the digitized value T(v, h) is "0" (namely, the determined result at step S107 is No), 1 is added to the value of the variable cnt [i] [j].

[0045]

At step S109, 1 is added to the value of a variable num [i] [j] that is a matrix. The variable num [i] [j] is a variable used to count the number of digitized values corresponding to pixels at coordinates (i, j) of the decoded picture. In other words, regardless of the determined result at step S107, whenever each digitized value T(v, h) is received, the value of the variable num [i] [j] is incremented by 1. Finally, the total number of digitized values corresponding to the pixels at the coordinates (i, j) of the decoded picture is stored as the value of the variable num [i] [j].

[0046]

Thereafter, the flow advances to step S110. At step S110, it is determined whether or not the user has performed the signal transmission stopping operation because a decoded picture with desired picture quality has been obtained. When the user has

performed the signal transmission stopping operation
(namely, the determined result at step S110 is Yes),
the flow advances to step S111. Otherwise, the flow
advances to step S104. The transmission stopping
5 operation is not limited to that performed by the user.
Alternatively, the transmission stopping operation may
be automatically performed when it is determined that a
decoded picture that satisfies a predetermine condition
has been obtained. A step for this operation may be
10 added to the flow chart shown in Figs. 7 and 8.

[0047]

When the transmission signal has been
completely sent (namely, the determined result at step
S104 is Yes) or when the signal transmission stopping
15 operation has been performed (namely, the determined
result at step S110 is Yes), the flow advances to step
S111. At step S113, the value of the variable i is
initialized. Thereafter, the flow advances to step
S112. At step S112, the value of the variable j is
20 initialized. Thereafter, the flow advances to step
S113. At step S113, the pixel value at the coordinates
(i, j) of the decoded picture is calculated and stored
to a variable O [i] [j] that is a matrix. In other
words, the value of the variable O [i] [j] is
25 calculated as the product of the ratio of the value of
the variable num [i] [j] that represents the total
number of digitized values corresponding to the pixels

at the coordinates (i, j) of the decoded picture and the value of the variable cnt [i] [j] that represents the number of digitized values that are not "0" in the digitized value and the gradation value depth of the decoded picture.

[0048]

Thereafter, the flow advances to step S114. At step S114, 1 is added to the value of the variable j. The operation performed at step S114 is equivalent to an operation of which the coordinates of the current pixel of the decoded picture is moved in the horizontal direction by one position. At step S115, it is determined whether or not the value of the variable i is smaller than the value of the variable pixel' (namely, the current pixel exceeds the array of digitized values of the decoded picture in the horizontal direction). When the value of the variable j is smaller than the value of the variable pixel' (namely, the determined result at step S115 is Yes), the flow returns to step S113. At step S113, pixel values of the decoded picture are set with the value of the variable j that has been set at step S114. Otherwise, the flow advances to step S116. At step S116, 1 is added to the value of the variable i. The operation performed at step S116 is equivalent to an operation of which the coordinates of the current pixel of the decoded picture is moved in the vertical

direction by one position.

[0049]

After the operation at step S116 has been completed, the flow advances to step S117. At step
5 S117, it is determined whether or not the value of the variable i is smaller than the value of the variable line' (namely, the current pixel exceeds the array of digitized values of the decoded picture in the vertical direction). When the value of the variable h is
10 smaller than the value of the variable line' (namely, the determined result at step S116 is Yes), the flow returns to step S112. At step S112, the value of the variable j is initialized. In addition, the pixel values of the decoded picture are calculated with the
15 value of the variable i that has been set at step S116. On the other hand, unless the value of the variable h is smaller than the value of the variable line' (namely, the determined result at step S117 is No), it is determined that all pixel values of the decoded
20 picture have been calculated. Thus, the decoding process is completed.

[0050]

Next, the relation between the picture quality of a decoded picture obtained according to the
25 embodiment of the present invention and the number of times of the digitizing process with threshold values will be described. Figs. 9, 10, and 11 show examples

of decoded pictures that are decoded from encoded data of which an original picture is digitized with threshold values four times, 32 times, and 400 times, respectively. Thus, it is clear that the picture quality of a decoded picture is proportional to the number of times of the digitizing process with threshold values. Thus, the user can clearly see a pattern or the like from the original picture. Picture portions of vehicles shown in Figs. 9, 10, and 11 are moving portions. Thus, when they are displayed as still pictures, they dim. However, when they are displayed with a displaying device that can display moving pictures (such as a television receiver), these pictures can be displayed in high picture quality.

[0051]

In the encoding process/decoding process for a picture signal according to the present invention, picture information is transmitted with encoded data of which similar digitized information is repeated. Thus, the encoding process/decoding process according to the present invention have several sufficient features that are not available in a conventional signal format for transmitting picture information. With such characteristics, various processes can be performed. As one of such features, the flexibility in the relation between an original picture and encoded data is large.

[0052]

For example, as shown in Fig. 12, when one pixel of an original picture is converted into a group of pixels of 100 (width) x 120 (height) each of which is composed of one bit, the original picture composed of 800 (horizontal) x 600 (vertical) pixels (each pixel is composed of eight bits (256 gradation levels)) can be converted into encoded data of an array of 80000 (= 800 x 100) (horizontal) x 72000 (= 600 x 120) (vertical) digitized values. In this case, width $w = 100$ and height $h = 120$ are just examples. In other words, the values of the width w and the height h may be varied for each device type or the like.

[0053]

When a picture with a gradation is decoded from a code, regardless of the size, the number of pixels, the gradation, and so forth of an original picture, the original picture can be decoded to a picture having any number of pixels and any number of gradation levels. For example, from encoded data of which each pixel of an original picture signal is converted into a group of pixels of 100 (w') x 120 (h'), each of which is composed of one bit (two gradation levels) (see Fig. 13), a picture composed of for example 667 (horizontal) x 360 (vertical) pixels having a desired number of gradation levels can be decoded. With any gradation value Dr' , a pixel value

I' is decoded corresponding to the following formula
(2) '.

[0054]

$$I' = Dr' \times p \quad \dots (2)'$$

5 where p represents the pixel density as with p in
formula (2).

[0055]

Next, with reference to Fig. 14, the above-
described encoding process/decoding process will be
10 described in detail. Fig. 14 shows an example of an
encoding process for encoding an original picture to
encoded data and a decoding process for decoding
encoded data to a decoded picture having any number of
gradation levels. For example, an original picture
15 composed of 800 (horizontal) x 600 (vertical) pixels
each of which is composed of eight bits (256 gradation
levels) can be converted into encoded data composed of
80000 (horizontal) x 72000 (vertical) digitized values.
More generally, when any number of digitized values in
20 the horizontal direction and any number of digitized
value in the vertical direction of encoded data
corresponding to one pixel of the original picture are
designated, any number of digitized values in the
vertical direction and any number of digitized values
25 in the horizontal direction of all the encoded data can
be designated.

[0056]

On the other hand, from encoded data composed of 80000 (horizontal) x 72000 (vertical) digitized values, a picture composed of 667 (horizontal) x 360 (vertical) pixels, each of which is composed of seven bits (128 gradation levels), can be decoded. More generally, when any number of digitized values in the horizontal direction of encoded data and any number of digitized values in the vertical direction of the encoded data corresponding to one pixel of a decoded picture are designated, a decoded picture having any size, any number of pixels, and any number of gradation levels can be obtained from the encoded data.

[0057]

As described above, in the encoding process/decoding process according to the present invention, it is clear that the flexibility in the relation between an original picture and a decoded picture is large. For example, a process for obtaining a decoded picture that is different from an original picture in the number of pixels, the resolution, the aspect ratio, and so forth can be performed (this process is referred as resizing process). When the number of pixels in the vertical direction and/or the number of pixels in the horizontal direction of the original picture is different from that of the decoded picture, the same effect as the linear interpolating process can be theoretically obtained.

[0058]

In the encoding process/decoding process according to the present invention, the flexibility of the format of a transmission signal is large. For example, as described above, the array of digitized values of encoded data corresponding to one pixel of an original picture can be designated corresponding to for example each device type. In addition, the flexibility of the positions of synchronous signals and encoding parameters (the size of the original picture, the number of pixels, the number of digitized values as an array of encoded data, and the number of times of the digitizing process) is large. Their positions can be designated for each device type. For example, header information may be contained in a transmission signal. In addition, encoding parameters may be contained in header information.

[0059]

In addition, according to the present invention, the flexibility of the decoding process can be improved. In other words, since picture information is transmitted with encoded data of which similar digitized information obtained by the digitizing process with threshold values is repeated, before all the encoded data is transmitted, as long as a synchronization that allows the sampling circuit 310 to sample the picture information at a proper timing is

established, the flexibility of the later decoding process becomes large. Thus, when the minimum unit of transmission data (for example, one packet) has been received, the decoding process can be started any time.

5 Thus, when the receiving process for a transmission signal is started, information for the synchronization is obtained. In the next sequence, with the information, the decoding process can be performed.

[0060]

10 In the decoding device 300, even if the value of the value of the cumulation times stored in the memory of the cumulating circuit 320 does not precisely match the real value of the cumulation times stored in the memory buffer, as long as the difference does not
15 affect the result of a dividing operation, the difference does not almost affect the accuracy of the reproduction of pixel values. Thus, it is not necessary to cause the calculations of the decoding process to exactly synchronize with the timing at which
20 stored values in the memory of the cumulating circuit 320 and the memory buffer are updated.

[0061]

Thus, the cumulating process of the cumulating circuit 320 and the calculating process of
25 the decoding circuit 330 can be performed in parallel. Consequently, in the middle of the signal transmission, an outline of the decoded picture (in particular, the

picture quality) can be observed. When the signal transmission is stopped corresponding to the observed result, desired picture information can be more effectively and quickly transmitted. In particular, when picture information with lower picture quality is transmitted corresponding to a decoding process that uses a relatively small amount of information contained in encoded data, a pseudo displaying process such as dither method can be performed at high speed. Of course, after much information has been transmitted, when the decoding process is performed in such a manner that the update timing of the values stored in the memory of the cumulating circuit 320 matches that of the memory buffer, a decoded picture with higher picture quality can be obtained.

[0062]

Alternatively, the user may cause the decoding side to transmit information with required picture quality for a decoded picture to the encoding side. The encoding side may set encoding conditions such as the number of times of the digitizing process with threshold values corresponding to the received information.

[0063]

As another alternative method, a part of a decoded picture may be used for non-picture information such as character information. As an example of the

method for displaying such information, when a part of an original picture is encoded, by using the maximum value or the minimum value of the dynamic range rather than random numbers as threshold value, the digitizing information corresponding to the portion can be flat. Alternatively, a portion of encoded data corresponding to any portion of an original picture may not be decoded.

[0064]

It should be noted that the present invention is not limited to the above-described embodiment. Instead, the present invention can be applied to various applications and modification within the scope thereof. Instead of generating encoded data composed having two gradation levels as a set of digitized values obtained by the digitizing process with threshold values, for example three types of threshold values may obtained with an uniformly distributed random number generator. With a quantizing process using these threshold values, encoded data having four gradation levels may be generated. In this method, almost the same effect as the present invention may be obtained.

[0065]

[Effects of the Invention]

As described above, according to the present invention, with reference to threshold values that are

set corresponding to uniformly distributed random numbers, pixel values of an original picture signal are digitized. Thus, encoded data that is a set of the digitized values is generated. Digitized values
5 sampled from such encoded data are cumulated. The cumulated value is divided by the number of cumulation times. Corresponding to the result of the dividing operation, a decoded picture is obtained.

[0066]

10 Such encoding process/decoding process for a picture signal are much simpler than those for a picture signal using the scanning line structure of for example the NTSC system. Thus, the structures for the encoding process/decoding process and the firmware can
15 be simplified.

[0067]

In addition, according to the present invention, since picture information is transmitted with encoded data of which similar digitized
20 information obtained by the digitizing process with threshold values is repeated, the flexibility of the format of a transmission signal can be improved. For example, the array of digitized values of encoded data corresponding to one pixel of an original picture can
25 be designated for each device type. In a process for adding synchronous signals and encoding parameters (such as the size of the original picture, the number

of pixels, the number of digitized values in encoded data, and the number of times of the digitizing process) to the encoded data and generating a transmission signal, the flexibility of the positions of the added information is large. Thus, the format of a transmission signal can be properly selected corresponding to the process for desired picture information.

[0068]

Alternatively, after an array of digitized values of encoded data is rearranged, they can be converted into a transmission signal. In this case, the picture quality of a part of a decoded picture can be prevented from largely deteriorating due to an error that takes place during the signal transmission or on a record medium. Alternatively, the conformity of the encoding process and the decoding process is assured.

[0069]

Because of the above-described flexibility of the format, the decoding process can be properly performed without need to sample all encoded data of the transmission signal. In other words, the decoding process can be performed with a predetermined ratio of all the digitized values of the encoded data. With a sampling period properly designated corresponding to a desired picture quality of the decoded picture or the like, the encoded data of the transmission signal can

be properly thinned out and sampled. Thus, the resolution and the number of gradation levels of the decoded picture can be properly selected. To do that, a memory and a calculating circuit necessary for
5 generating a decoded picture having desired resolution and desired gradation levels are added to the decoding device. Thus, the cost of the decoding device can be reduced.

[0070]

10 Because of the flexibility of the format and the feature of which even if the number of cumulation times of the memory does not accurately match the number of cumulation times of the memory buffer, the difference does not substantially affect the picture
15 quality of the decoded picture, the flexibility of the decoding process can be improved. In other words, before all the encoded data has been completely transmitted, under a particular condition of which a synchronization is established, the decoding process
20 can be performed. Thus, the receiving process for the transmission signal and the decoding process thereof can be performed in parallel.

[0071]

25 Thus, in the middle of the signal transmission, an outline of a decoded picture (in particular, the picture quality thereof) can be observed. Corresponding to the observed result, the

signal transmission can be stopped. Consequently,
desired picture information can be more effectively and
quickly transmitted than the conventional method. When
a signal is quickly transmitted by a decoding process
5 using a relatively small amount of information of
encoded data, a pseudo displaying process such as
dither method can be performed without the increase of
the load of calculations of the decoding device.
Alternatively, the user may cause the decoding side to
10 transmit information with required picture quality for
a decoded picture to the encoding side. The encoding
side may set encoding conditions such as the number of
times of the digitizing process corresponding to the
received information.

15 [0072]

Because of the flexibility of the decoding
process, in a storage type broadcasting service or the
like, both a process for transmitting an outlined
picture in a short time and a process for transmitting
20 a precise picture in a relatively long time can be
accomplished.

[0073]

Moreover, in the encoding process/decoding
process according to the present invention, the
25 flexibility in the relation between an original picture
and a picture decoded from encoded data becomes large.
Thus, the resizing process of which a decoded picture

that is different from an original picture in the number of pixels, the resolution, the aspect ratio, and so forth is obtained can be performed. In this case, the same effect as the linear interpolating process can be obtained. In addition, a process for causing a part of an original picture not to be displayed can be easily performed.

[0074]

The information unit of encoded data according to the present invention is small. In addition, with a combination of the resizing process and the process for causing a part of an original picture not to be displayed, a function for simultaneously displaying character information and a plurality of pictures can be accomplished.

[0075]

The information unit of encoded data according to the present invention is small. In addition, the gradation levels of a decoded picture are obtained from encoded data of which the digitizing process is performed with threshold values a plurality of times. Thus, the influence of an error that takes place in a transmission signal against a decoded picture is small. Consequently, very high robustness can be accomplished. In addition, since encoded data of which pixel values are digitized with threshold values is a set of digitized values each of which is

composed of one bit (thus, there is no correlation thereof), theoretically, an error does not propagate. Consequently, even if the communication environment, the record medium, and so forth do not have high reliability, a good decoded picture can be obtained.

[Brief Description of the Drawings]

[Fig. 1]

Block diagram for explaining the overall structure of an embodiment of the present invention.

[Fig. 2]

Schematic diagram for explaining a digitizing process with threshold values according to the embodiment of the present invention.

[Fig. 3]

Schematic diagram for explaining an encoding process according to the embodiment of the present invention.

[Fig. 4]

Schematic diagram for explaining encoded data generated according to the embodiment of the present invention.

[Fig. 5]

Part of a flow chart for explaining the encoding process according to the embodiment of the present invention.

[Fig. 6]

Another part of the flow chart for explaining

the encoding process according to the embodiment of the present invention.

[Fig. 7]

5 Part of a flow chart for explaining a decoding process according to the embodiment of the present invention.

[Fig. 8]

10 Another part of the flow chart for explaining the decoding process according to the embodiment of the present invention.

[Fig. 9]

Schematic diagram showing an example of a decoded picture according to the embodiment of the present invention.

15 [Fig. 10]

Schematic diagram showing another example of a decoded picture according to the embodiment of the present invention.

[Fig. 11]

20 Schematic diagram showing another example of a decoded picture according to the embodiment of the present invention.

[Fig. 12]

25 Schematic diagram for explaining the relation between one pixel of an original picture and an array of digitized values of encoded data.

[Fig. 13]

Schematic diagram for explaining the relation between an array of digitized values of encoded data and one pixel of a decoded picture.

[Fig. 14]

5 Schematic diagram showing an example of the relation among an original picture, encoded data, and a decoded picture.

[Explanation of Main Reference Numerals in the Drawings]

10 100 ... Encoding device, 110 ... Uniformly distributed random number generator, 120 ... Quantizing device, 300 ... Decoding device, 310 ... Sampling circuit, 320 ... Cumulating circuit, 330 ... Decoding circuit

15

[Title of Document] Abstract

[Abstract]

[Purpose]

To allow any resolution and any gradation
5 levels of a decoded picture to be selected in a picture
signal process.

[Construction]

A quantizing device 120 of an encoding device
100 repeatedly digitizes an original picture signal
10 with reference to random numbers supplied from a
uniformly distributed random number generator 110 and
generates encoded data as a set of digitized values. A
transmission signal generating device 200 converts the
generated encoded data into a transmission signal. A
15 sampling circuit 310 of the decoding device 300 samples
the digitized values of the encoded data of the
transmission signal and supplies the sampled values to
a cumulating circuit 320. The cumulating circuit 320
cumulates the sampled values and updates the number of
20 times of the sampling operation. Corresponding to the
stored digitized values and the number of times of the
sampling operation, the decoding circuit 330 calculates
pixel values of the decoded picture. Since the picture
information is transmitted with the encoded data of
25 which similar digitized information is repeated, the
flexibility of the transmission signal format can be
improved.

[Selected Drawing] Fig. 1